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Simple Harmonic Motion (SHM):

- Derivation to show equation of motion of object in SHM:

$$F = -kx$$

$$ma_x = -kx$$

$$a_x = -\frac{k}{m}x$$

$$\omega^2 = \frac{k}{m}$$

$$\frac{d^2x}{dt^2} = -\frac{k}{m}x$$

$$v = \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

$$x(t) = A\cos(\omega t + \varphi)$$

$$\frac{dx}{dt} = -\omega A\sin(\omega t + \varphi)$$

$$\frac{d^2x}{dt^2} = -\omega^2 A\cos(\omega t + \varphi)$$

$$-\omega^2 A\cos(\omega t + \varphi) = -\omega^2 A\cos(\omega t + \varphi)$$

This is the base function ... define ω^2 based on physical values

- Definitions:

$x(t)$ → position (displacement) of the mass at a certain time [m]

$v(t)$ → velocity at certain time [m/s]

$a(t)$ → acceleration at certain time [m/s^2]

A → maximum amplitude [m]

φ → phase constant; some angle at $t = 0$ [rad. or deg.]

ω → angular frequency [rad/s]

T → period: time to complete 1 revolution [s] $T = \frac{2\pi}{\omega}$

f → oscillations per time interval [$s^{-1} = Hz$]

- Equations:

$$T = \frac{1}{f}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$$

$\omega^2 = \frac{k}{m} \Rightarrow \omega = \sqrt{\frac{k}{m}}$

$$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$\omega = 2\pi f$$

- Equations continued:

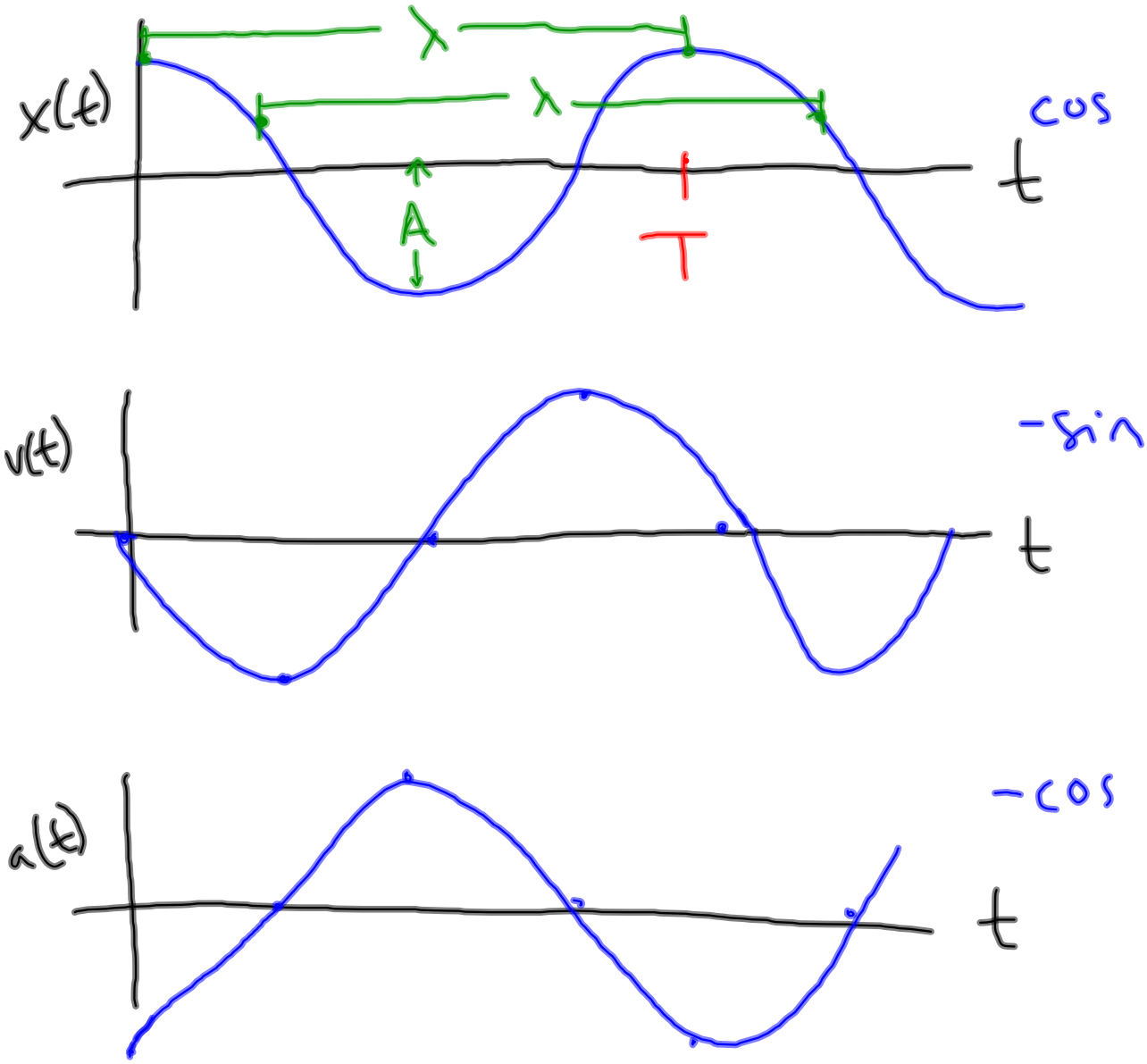
$$x(t) = A\cos(\omega t + \varphi)$$

$$v(t) = -\omega A \sin(\omega t + \varphi)$$

$$a(t) = -\omega^2 A \cos(\omega t + \varphi)$$

$$v_{max} = \omega A = \sqrt{\frac{k}{m}}\,A$$

$$a_{max} = \omega^2 A = \frac{kA}{m}$$


x(t)
λ
λ
A
T
cos
t
v(t)
-sin
t
a(t)
-cos
t

A 200 g block connected to a light spring for which the force constant is 5.00 N/m is free to oscillate on a horizontal, frictionless surface. The block is displaced 5.0 cm from the equilibrium and released from rest.
a) Find the period of its motion.
b) Determine the maximum speed of the block.
c) What is the maximum acceleration of the block?
d) Express the position, velocity, and acceleration as functions of time.

a) $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$

$= 1.26\ s$

b) $V_{max} = \omega A = \sqrt{\frac{k}{m}}\,A$

$= .25\ m/s$

c) $a_{max} = \omega^2 A = \frac{kA}{m}$

$= 1.25\ m/s^2$

d) $\varphi = \emptyset$

$x(t) = (.05\ m)\cos(5t)$

$v(t) = -(.25\ m/s)\sin(5t)$

$a(t) = -(1.25\ m/s^2)\cos(5t)$